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EMERGENCY ESCAPEWAYS FROM COAL MINES

BY

R. T. ARTZ AND O. V. SIMPSON

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EMERGENCY ESCAPEWAYS FROM COAL MINES[1/]

By R. T. Artz[2/], and O. V. Simpson[2/]

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INTRODUCTION

The provision of escapeways from coal mines is a moral and, in most States, a legal obligation of mine owners and operators. The obligation is not always fulfilled because of the hope that no occasion will ever arise requiring the use of such facilities, and, as time passes without the need for using them, a false sense of security is born in the belief that "it can't happen here."

The disastrous fire in a mine in Ohio on July 5, 1944, again focused attention on the importance of escapeways in averting disasters and made it clear that one or more dependable exits must be provided from a mine and parts

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7478."

2/ Coal-mine inspectors, Health and Safety Division, Bureau of Mines, Pittsburgh, Pa.

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thereof where men might be trapped by being cut off from the regular travel route. This matter of always having available travelable exits has been advocated for many years by the United States Bureau of Mines.

As a result of the Ohio disaster, many operators examined conditions in their mines relative to escapeways and formulated plans for establishing and maintaining them. Procedures to be followed by mine officials in combating a mine fire have been established by many mine operators, and groups of operators have formed voluntary organizations to function when a disaster occurs at a member mine. While the primary function is assistance during rescue and recovery operations following a disaster, the organization is usually flexible enough to function while combating a serious mine fire.

A brief description of several recent mine fires and of methods used by some mine operators to protect their workmen by providing escapeways is set forth in this circular. Several methods for escape of workers from a mine following an explosion or fire are discussed. The utility of large-diameter boreholes as escapeways is discussed at length, because this method of providing escapeways is believed to be meritorious.

ACKNOWLEDGMENT

Information has been collected from various sources and can be acknowledged only as a whole because of the desire of some agencies for anonymity; especial acknowledgment is due G. W. Grove, of the Bureau of Mines, for assistance in obtaining the information, and to F. C. Sturges, vice-president, Pennsylvania Drilling Co., Pittsburgh, Pa., who furnished the information and pictures concerning large-diameter boreholes.

MAJOR COAL-MINE FIRE DISASTERS IN 1944

Two major coal-mine fire disasters occurred in 1944; one was in Pennsylvania and one in Ohio. Six lives were lost in the former and 66 lives in the latter. The Ohio disaster was the worst coal-mine fire disaster since 1911, when a fire in a Pennsylvania anthracite mine caused the death of 72 men. The disaster at Cherry, Ill., in 1909, in which 259 lives were lost, was the worst in the history of coal mining in the United States.

Mine A Disaster

A fire occurred in an Ohio coal mine on July 5, 1944, when an arc was caused by a dislodged trolley wire in contact with a track rail and a discarded hoisting rope. A timberman scaling the roof along the haulageway caused a fall of roof coal and rock, which pulled the trolley wire out of a trolley frog. The dislodged trolley wire struck the track rail first, and the timberman pushed it aside and into contact with the partly buried and discarded rope, which heated and acted as a source of ignition for a considerable distance. The resulting short circuit was not sufficient to trip the circuit breaker, which was set for a load of 3,400 amperes, slightly more than the normal load of the circuit. The circuit breaker was tripped manually about 40 minutes after the wire was dislodged.

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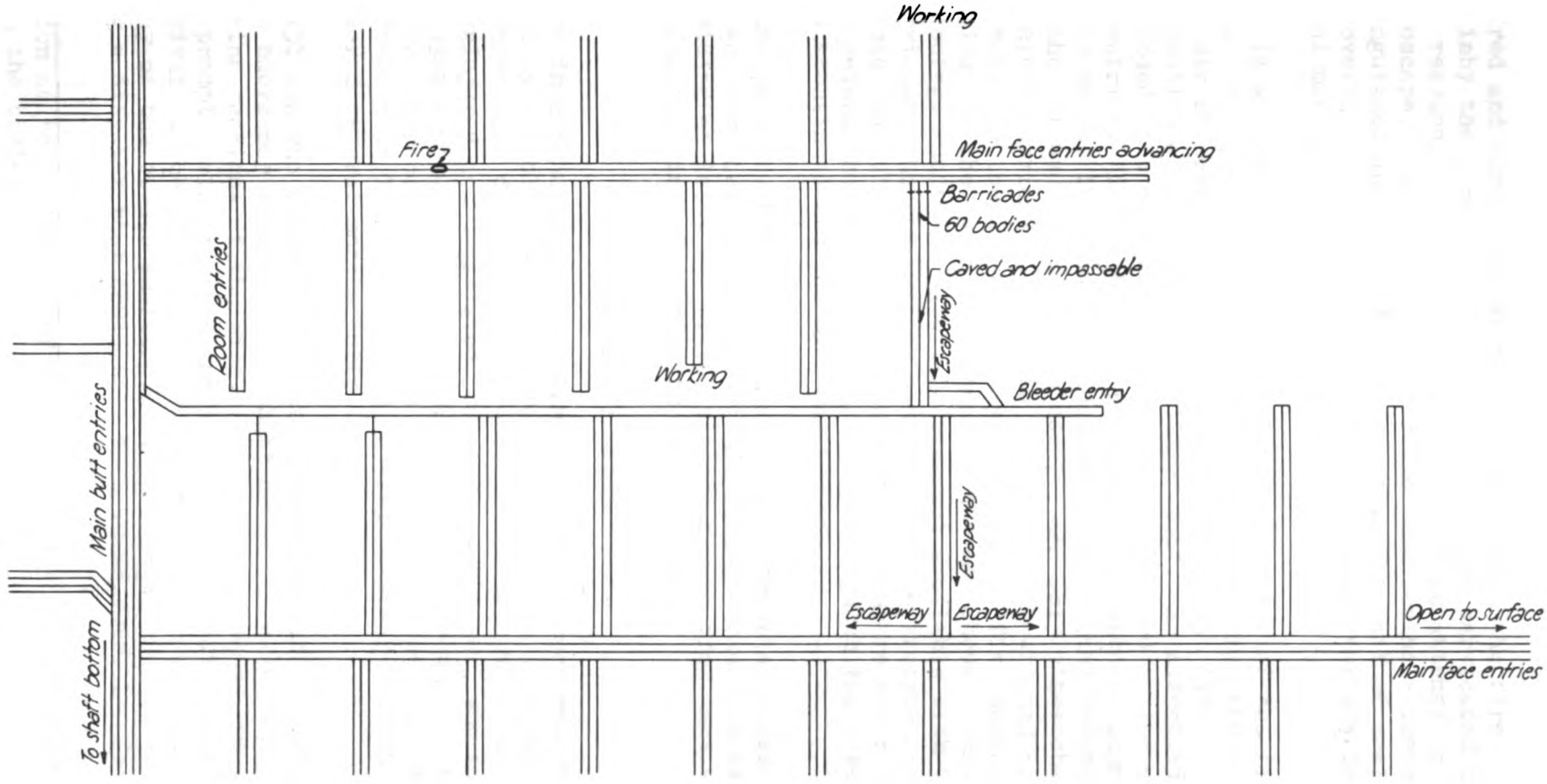

Figure 1. - Sketch of fire area at mine "A" showing escape route.

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One hundred and ninety men were in the mine when the fire occurred; 66 were trapped inby the fire, and, although 60 of them barricaded themselves, they were not rescued; the other 6 victims died in an attempt to get around the fire and escape. The fire area was sealed and months elapsed before the fire was extinguished and the bodies recovered. The task of sealing this fire and later recovering the fire area was one of the most formidable in the history of coal mining.

Figure 1 is a sketch showing the relative position of the fire and the inby workings. The foreman, upon detecting the smoke from the fire, short-circuited the air at several places on the inside of the fire in an effort to reduce contamination of the air in the danger zone. He assembled the workmen and they proceeded to a room entry known to be connected to the adjacent set of main face entries. Escape by this route was prevented by impassable falls in the vicinity of No. 18 room. Considerable time elapsed before the trapped men realized that it was impossible to escape; the only other chance of survival was to erect barricades. By this time about 3 hours had elapsed since the fire started, and the air was contaminated by the fire gases, despite short-circuiting, to the extent that many of the men showed signs of carbon monoxide poisoning. Suitable materials were not available with which to erect effective barricades thereby further handicapping the trapped men. It was later determined that the men had expired within 11 hours after the fire started3/ and several hours before efforts to extinguish the fire by direct attack were discontinued and the mine was sealed.

If the escape route had been maintained in a travelable condition, the death toll might have been much lower. This is an outstanding example of the need for providing at least two travelable escapeways from each working section and keeping them in safe condition for travel.

Mine B Disaster

This fire in a Pennsylvania bituminous-coal mine occurred June 7, 1944, and was caused by a trolley wire that fell on four mine cars filled with horse feed. One hundred and fifty-seven men were in the mine when the fire started; 151 escaped uninjured and unassisted, but the other 6 men, who were working on the main haulageway about 1,500 feet inby the fire, presumably were suffocated. The bodies were not recovered immediately, and work of sealing the mine openings was started about 17 hours after discovery of the fire; the bodies were finally recovered several months later.

Of the 151 men who escaped unassisted, 146 were working inby the fire and escaped by an emergency stairway in a shaft about 3.5 miles inby the fire and near the working sections of the mine. The escape of these men was made possible by the prompt instructions given by the mine superintendent, shortly after his arrival at the mine, for the workmen to proceed immediately to the surface by way of the escape shaft. Thus, an emergency escapeway is credited with averting a disaster that could have been worse than the disaster at mine A.

3/ Information as to activities of the trapped men was obtained from notes found on the bodies.

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DISASTER AVERTED BY ESCAPEWAYS

Numerous disasters have been averted when men inby a fire escaped through properly maintained escapeways. At a mine having adequate escapeways and with officials trained in the proper procedure for removing men from affected areas or danger zones, management is relieved considerably and is able to exert every effort in combating the fire. A case in point follows:

Mine C

A fire occurred at the bottom of the main hoisting slope of an Ohio coal mine on October 23, 1944. The mine is opened by two rock slopes about 5 miles apart and by a shaft. Two hundred and sixty-five men were in the mine when the fire occurred. Two hundred and sixty-four men escaped unassisted, and one man was asphyxiated when he attempted to escape by traveling through the fire gases without respiratory protection; another man accompanying him succeeded.

The fire started when a makeshift electric heater in a pump station at the bottom of the slope overheated and ignited combustible material in the station. The men in the working sections escaped through the supply slope, which had been completed 5 months previously. The deceased and his companion were working about 700 feet inby the fire. About 11 hours of concerted effort was required to extinguish the fire, in which 17 mine cars were destroyed and 225 feet of entry collapsed. Unquestionably, the nearness of the supply slope to the working sections of the mine and the prompt removal of the workmen through this opening were responsible for averting a disaster.

This is one of many instances on record of lives saved when men escaped through escapeways, and undoubtedly numerous others have occurred but were not recorded because of the absence of anything spectacular. The value of escapeways is inestimable. They may be utilized for ventilation, thereby maintaining or sometimes even improving the efficacy of an ever-expanding ventilating system. In fact, the entire economy of mine operation may be benefited by judiciously placed escapeways or additional mine openings.

MINE ESCAPEWAYS

The entrapment of mine workers by a fire is a situation feared by workmen and officials alike. Escapeways are required by most mining laws, but enforcement of the law is often neglected, mainly because many mine operators plead lack of funds and the enforcing agency does not insist on strict compliance with the law. Consequently, the hazard automatically created is augmented by the attitude that "it can't happen here." Mining engineers are aware of the moral, legal, and economic need of multiple mine openings and interconnected mine workings, and a soundly engineered plan for development and mining usually embraces these features. However, the intention of the engineer is often ignored by the persons responsible for executing the plan.

A mine escapeway may be defined as a mine passageway that has been designated as an alternate route of travel which is maintained in a safe and healthful condition at all times and through which persons may travel between

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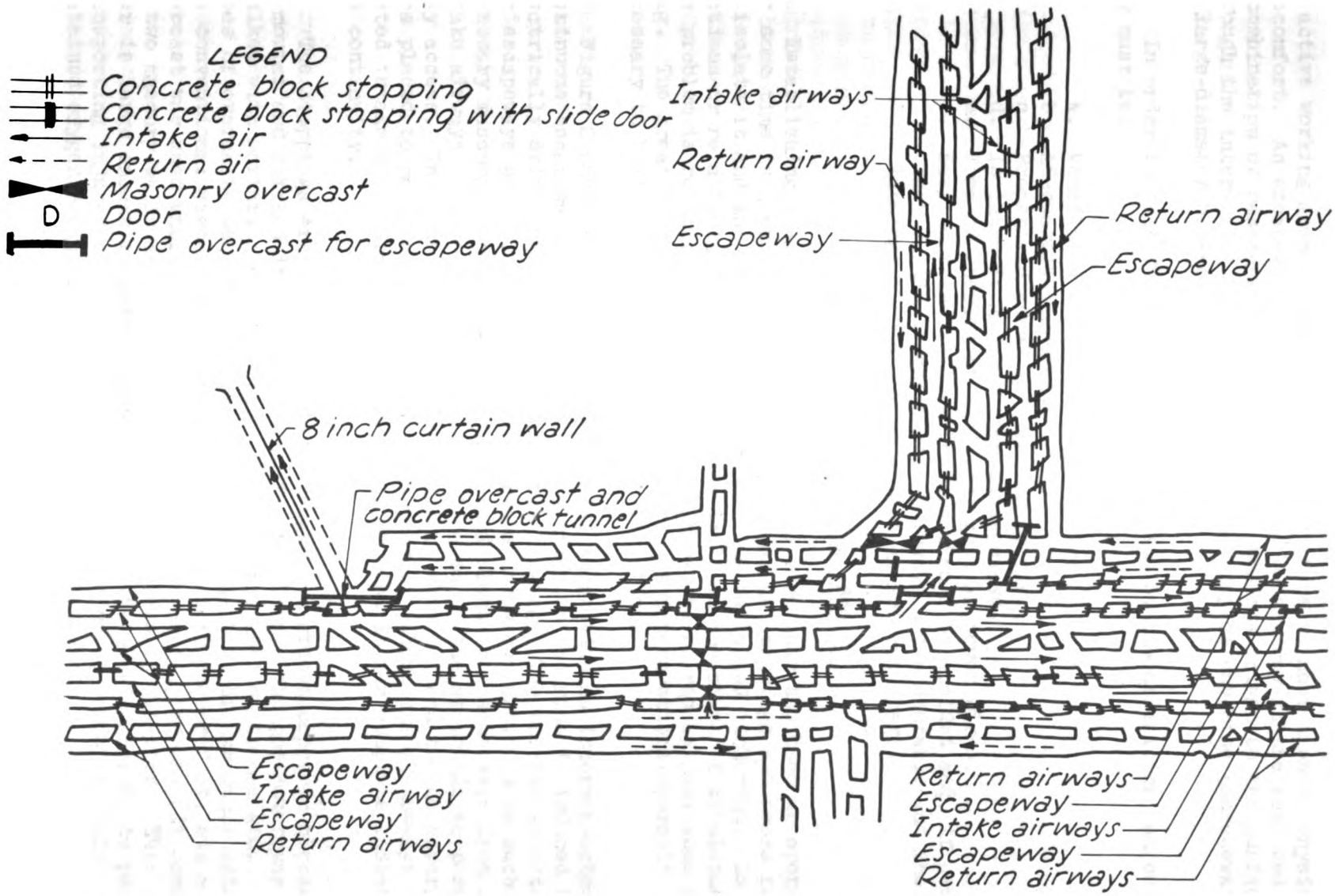

Figure 2. - Junction of main entries, showing position of facilities forming an interconnected and continuous escapeway.

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an active working area of the mine and the surface without unusual physical discomfort. An escapeway may be a continuous passageway in the coal bed or a combination of passageways in the bed and openings driven to the surface through the intervening ground. Such openings may be any mine passageways or large-diameter boreholes.

In order to satisfy the conditions imposed by the definition, an escapeway must be:

a. Ventilated with good-quality air.
b. Adequately timbered.
c. Properly drained and free of debris.
d. Isolated from other mine passageways.
e. Free of sources of ignition, such as power wires.
f. Easy to travel. Long ladders should be avoided and, if used, they should be enclosed; stairways are preferable and the landings should not be more than 10 feet apart.

Escapeways in the Coal Bed

Establishing a system of escapeways in a mine that has been in operation for some time is a problem because of the numerous stoppings and doors required to isolate it and the work involved in removing falls and timbering. In active sections or relatively new mines or mines still in the state of development, the problem is relatively simple and usually may be solved by judicious planning. The greatest difficulty is encountered at intersections where it is necessary to build overcasts for complete isolation.

Figure 2 shows the facilities installed to provide an interconnected and continuous escapeway in a mine. Air circulation in the mine is induced by an electrically driven axial-flow fan operated blowing. The entries selected for escapeways were originally intake airways and were continued as such. The necessary masonry stoppings were erected to isolate the escapeways from other intake airways. Slide doors were placed in some of the stoppings to permit easy access. The entries were drained, debris removed, and the necessary timbers placed to make them safe and easy to travel. Where the escapeways intersected intake or return airways, overcasts were built for complete isolation and continuity.

The stoppings erected were made of tongue-and-groove concrete blocks laid in mortar and hitched into the ribs, roof, and floor. The perimeter was caulked with mortar, and a face coat of mortar was applied to one side. Two types of overcasts were built where it was necessary to bridge other entries. The conventional masonry type was used where the duty required it, but a pipe overcast was used where the only duty is the passage of persons. It consists of two masonry walls and a connecting pipe 42 inches in diameter. This diameter is large enough to permit uninjured men to travel unhampered, to permit transporting injured men on stretchers, and to permit men wearing self-contained oxygen breathing apparatus to crawl unhampered.

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The slope shown is a main return airway. The stairway is isolated from the return air by a substantial masonry curtain wall 8 inches thick. The overcast at the foot of the slope consists of a pipe overcast and a tunnel made of concrete blocks. The pipe bridges the track at the landing, and the tunnel extends from the pipe to a point in the escapeway inby the return airway.

Figure 3 is a portion of a mine map showing one active section and the facilities installed to provide a continuous and interconnected escapeway from the working section to the surface; it is possible to escape from the working section either through the room-entry escapeway or through the bleeder-entry escapeway and thence to the surface. As originally received, the plan did not show isolated escapeways in the room entries. The plan was revised to show this as well as the sequence of mining, and the revision is considered justifiable because a specific example has more merit than a general plan.

A track haulage system is installed in the main and face entries. Mobile mechanical loading machines and shuttle cars are used in the development of all entries. Belt conveyors are installed in the room entries following development for transporting the coal mined in the rooms, and shaking conveyors are used in the rooms. Supply tracks are installed in the outer room entries. The coal in the pillars is not recovered. A retreat sequence of extraction is followed in winning the coal tributary to room entries. Groups of five rooms, each 26 feet wide and on 40-foot centers, are advanced simultaneously on each side of the room entry, and a solid pillar of 54 feet is left in place between each group. The sequence of mining alternates from side to side of the face entry.

Stoppings, doors, and overcasts are used to isolate the escapeways from other mine passageways. Doors in the face entries and near the entrance to the room entries are normally open because of rail traffic. They do not disturb the ventilating current and may be closed to isolate the escapeway. The overcasts at the entrance to the belt conveyorway are used to elevate the belt conveyor for convenient discharge into the mine cars but are also links in the chain of isolating facilities. Furthermore, the door placed at the inby end of the conveyorway reduces the air flow in this entry to leakage, thereby reducing the amount of dust suspended from the coal in transit.

The original plan specified one line of stoppings in the room entry; however, the additional line is an improvement. Aside from alleviating the dust hazard and forming a continuous isolated escapeway from the working face to the surface, separate air splits are provided for each group of rooms, and straight line airflow is achieved by returning the air via the bleeders, because the room entries are maintained throughout during the period of mining activities, which usually is 2 months with three-shift operation.

The skeleton mine map (fig. 4) shows an interconnected system of escapeways. These routes of travel are ventilated by intake air, and by manipulating the fire doors it is possible to isolate a fire area and prevent the fire gases from hampering the escape of the men. Similar systems have been devised for many mines, and men are well-informed as to the procedure in the event of a fire.

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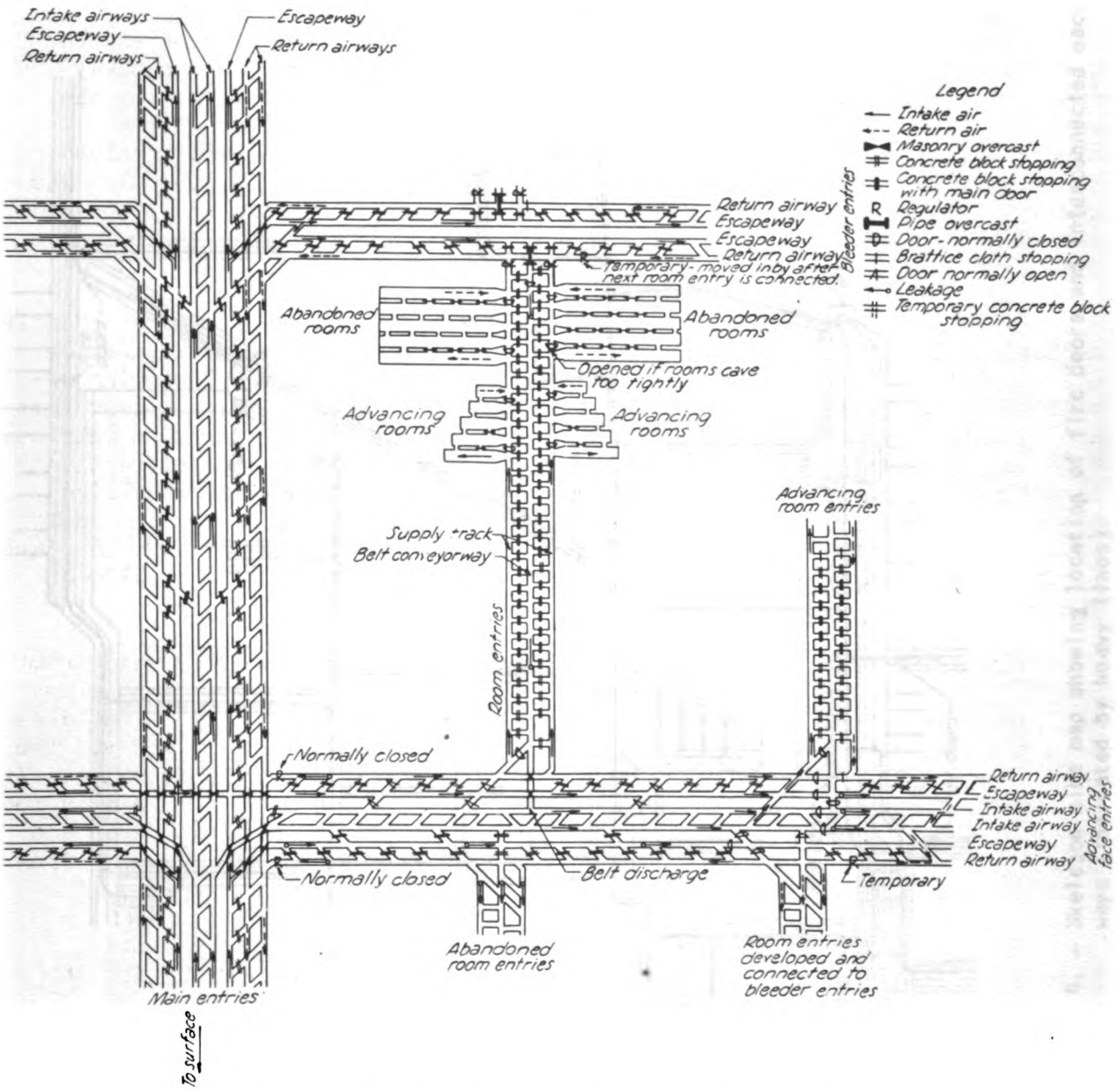

Figure 3. - Interconnected escapeway system.

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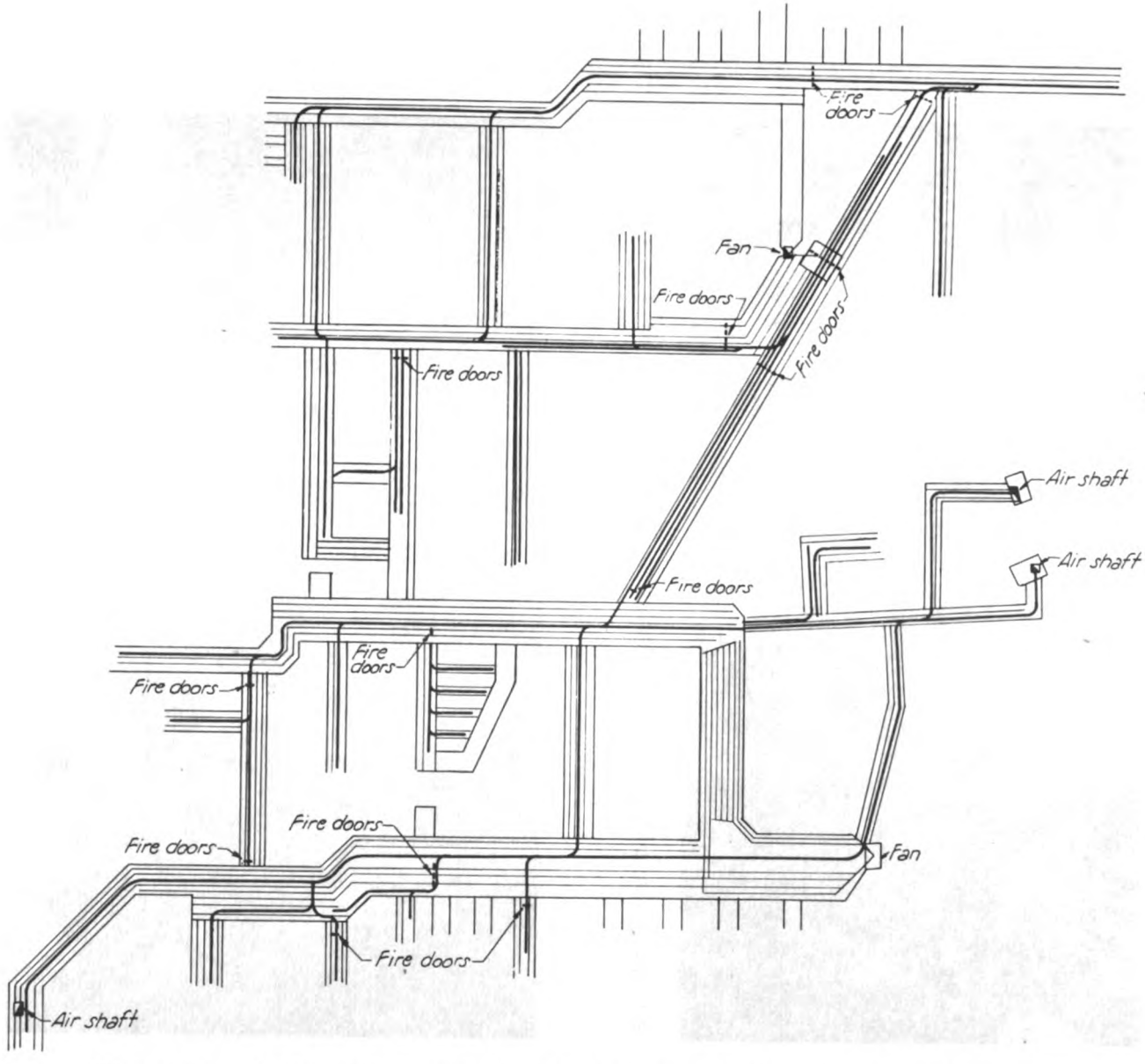

Figure 4. - Skeleton mine map showing location of fire doors and interconnected escapeways (indicated by heavy lines).

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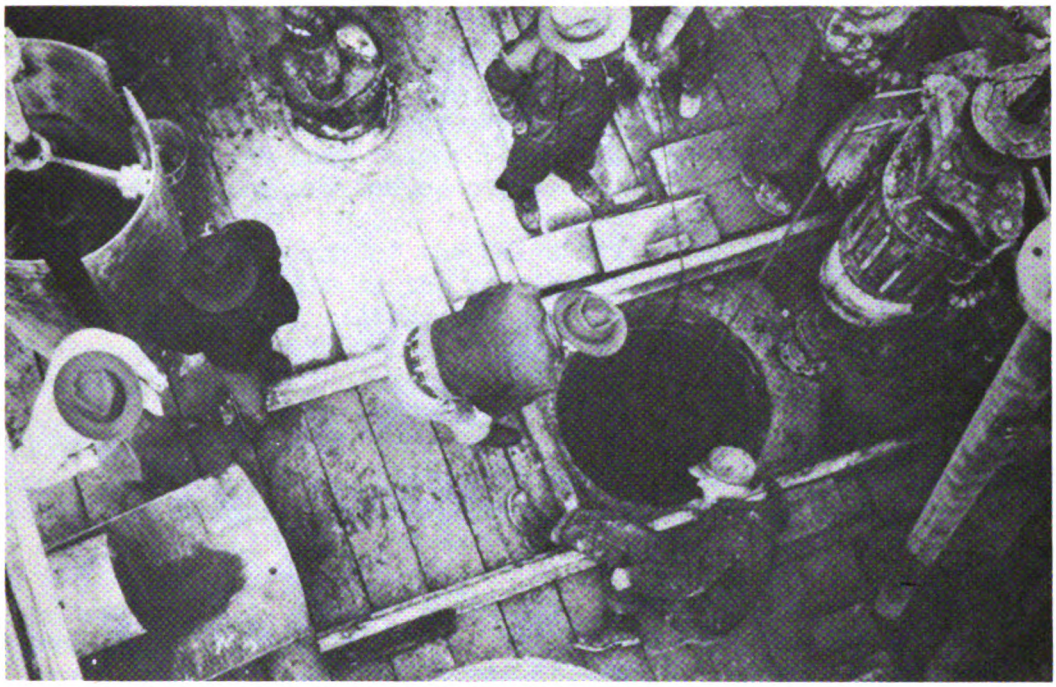

Figure 5. - View looking down upon the top of a hole showing the concrete collar.

Figure 6. - Pieces of core removed from the hole.

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Large-Diameter Boreholes

The sinking of shafts and slopes through strata overlying a coal bed is a costly project; costs range from $25 upward per cubic yard, depending on the size and shape of the opening and the type of lining used. Conventional techniques for excavating these openings are well known, and many persons engaged in this type of work have long sought changes and improvements that would increase rates of sinking and reduce costs.

Following the development of the Calyx drill about 1888, mining engineers and others began to speculate on the possibilities of boring holes large enough in diameter to be of use in mining, particularly as an aid in improving ventilation. During the decade 1930-1940, numerous holes were bored in and at metal mines for ventilation, the diameters ranging from 48 to 66 inches and depths from 200 to 1,200 feet. During 1942-1944, a 66-inch-diameter hole was bored to a depth of 2,500 feet at an iron mine in Wisconsin. The successful completion of these holes demonstrated conclusively the feasibility of large-diameter boreholes and revived interest in their possible application in coal mining as emergency escapeways and as an aid to ventilation.

Large-diameter boreholes are a solution to the problem of providing escapeways from mines now lacking an interconnected and continuous system of escapeways, particularly those mines where the intake and return openings are several miles apart and the cost of providing isolated escapeways would be high. These holes possess certain advantages over unlined shafts sunk by conventional methods: The walls are smooth and usually self-supporting, except when extremely weak strata or heavy ground are encountered; and resistance to airflow is a minimum because of the smooth walls.

While the authors are not aware of large-diameter holes sunk in connection with coal mining, two 36-inch-diameter holes have been bored through coal-bearing formations at clay mines in Ohio. Clay is being mined from the formation underlying the Lower Kittanning coal bed. Pertinent information[4/] about the holes follows:

The holes were started on the surface in the Conemaugh formation and penetrated the Allegheny formation, cutting 67 feet of the former and 173 feet of the latter. The Conemaugh formation is chiefly sandstone, whereas the penetrated part of the Allegheny formation consisted of the Upper Freeport coal, the Butler sandstone, the Bolivar clay, the Lower Freeport coal, the Freeport sandstone, the Upper Kittanning coal, the Worthington sandstone, the Middle Kittanning coal, the Lower Kittanning coal, and the Lower Kittanning underclay. A concrete collar and concrete lining extending 22 feet were constructed to support the unconsolidated material overlying the firm strata. Figure 5 is a view looking down upon one hole, showing the concrete collar. Note the drill transmission case swung aside to permit removal of a section of the core. Figure 6 shows some of the core removed from the one hole.

4/ Information supplied by F. C. Sturges, vice president, Pennsylvania Drilling Co., Pittsburgh, Pa., together with photographs and permission to publish and reproduce them.

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A diamond-drill rig modified to accommodate a chilled-shot coring bit was used. It is powered by a 6-cylinder internal-combustion engine rated at 67 horsepower and equipped with a 10-foot core barrel. Drill rods extending from the drill head transmit rotative power to the bit. Figure 7 is a view of the rig showing the drill head. Drill-rod guides were placed at intervals to centralize the rods and to prevent whipping. Whipping of the drill rods and diameter of the hole are factors that determine the depth to which a large-diameter hole may be sunk, usually 300 feet for a 36-inch-diameter hole. For boring larger holes to greater depth, a rodless type of drill rig is available commercially.

Whereas the holes were sunk primarily to serve as airways, they may also be used as escapeways if suitable hoisting equipment is available, which might consist of a mobile unit on which a hoist and gin pole are mounted. Cages have been designed and built for use in large-diameter boreholes. Figures 8 and 9 shows a cage built for use in 36-inch-diameter holes. It is large enough to accommodate two men. Of course, larger holes would accommodate larger cages, and more men could be hoisted each trip.

EXPEDIENTS FOR ESCAPING

Providing escapeways that will be serviceable under all conditions following mine fires and explosions is almost impossible. A danger zone usually surrounds a fire and an explosion area, through which uninjured workers may be forced to travel to reach the escapeway. Fire originating in room necks or any other part of an active section or a local gas explosion may contaminate the general air of the section with poisonous gases, and uninjured workers may have difficulty in reaching the escapeway. Also, fire gases from other sections of the mine may contaminate the general air of unaffected areas, thus hindering escape. To meet such situations, plans and devices have been devised to assist workers in saving their lives.

Miner's Self-Rescuer

The miner's self-rescuer is a pocket-size respirator that protects the wearer against asphyxiation by carbon monoxide. A worker escaping injury by a fire or explosion is threatened with two hazards: (1) he may be poisoned by carbon monoxide or (2) suffocated because of a lack of oxygen. A self-rescuer will protect the wearer for at least half an hour and thus enable him to escape through an atmosphere containing carbon monoxide, provided the atmosphere also contains enough oxygen to sustain life.

The self-rescuer consists of a canister and hermetically sealed carrying case. The canister contains cotton, granular fused calcium chloride, hopcalite, suitable separators, and is equipped with inhalation and exhalation valves, a mouthpiece, and a nose clip. The carrying case weighs about 20 ounces, and the canister, including mouthpiece and nose clip, weighs about 15 ounces. The cotton acts as a filter to remove smoke; the calcium chloride absorbs water vapor; and the hopcalite oxidizes the carbon monoxide to carbon dioxide. The exhalation and inhalation valves control the coursing of the air through the canister and to and from the mouthpiece. Air being inhaled is

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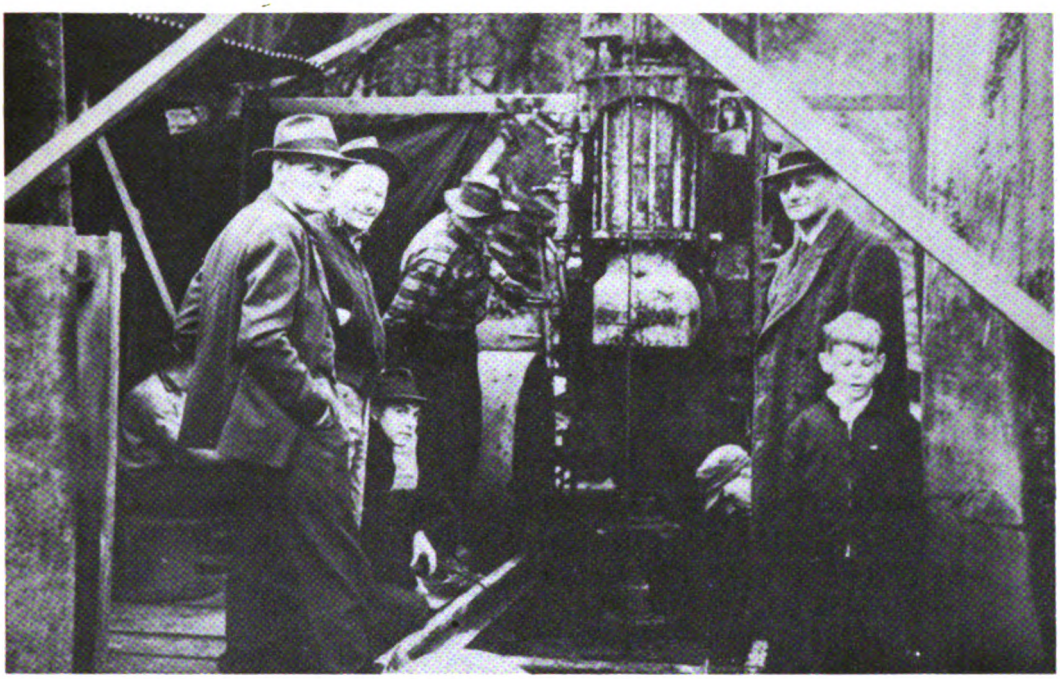

Figure 7. - View of drill rig showing the drill head.

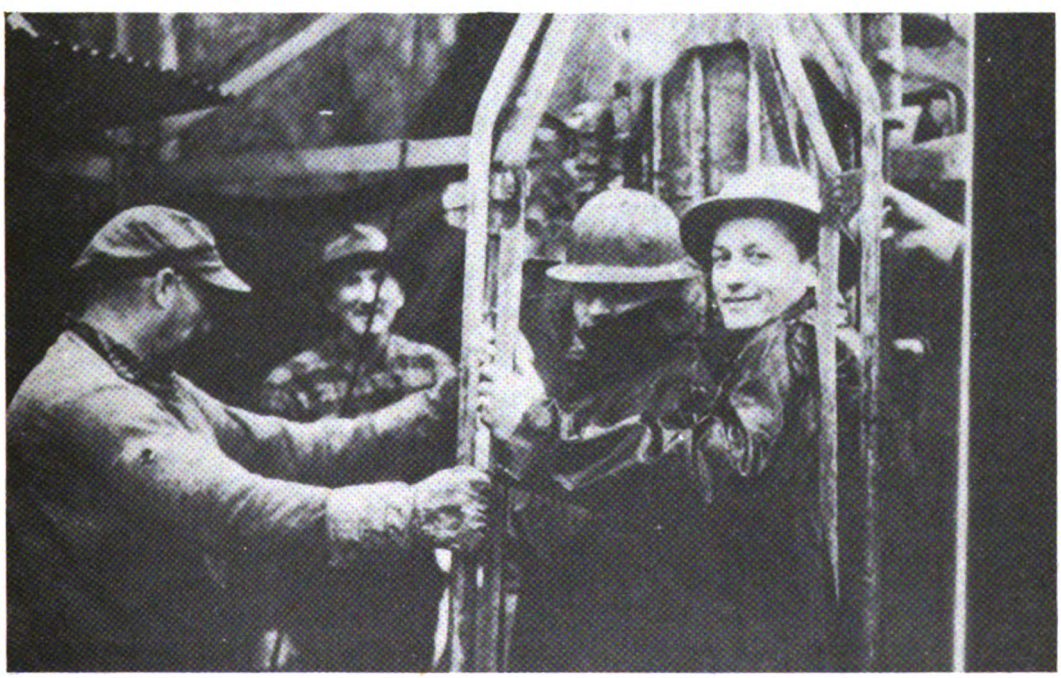

Figure 8. - Men on cage preparatory to descending a 36-inch drill hole.

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Figure 9. - Cage for use in 36-inch diameter drill holes.

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Have your Self-Rescuer with you at all times. Take good care of it; do not bump or damage it.

To open the case in which the Self-Rescuer is sealed, put your finger in the ring at the side of the case and give a strong upward pull.

Lift the Self-Rescuer out of the case.

Put the rubber mouthpiece in your mouth between your lips and teeth, and bite on the rubber lugs. Put the nose clip TIGHTLY over your nose, as you must breathe only through your mouth.

Now you are wearing the Self-Rescuer correctly. Go outside, or to fresh air, quickly but carefully.

Figure 10. - How to use the self-rescuer.

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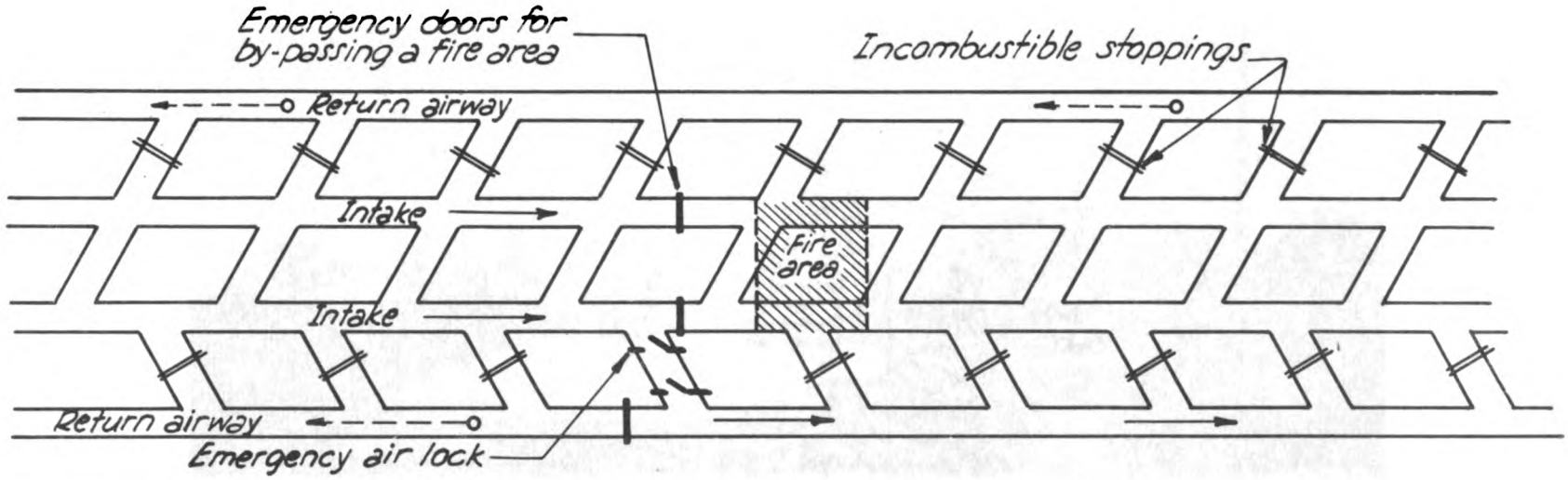

Figure 11. - Method of by-passing a fire.

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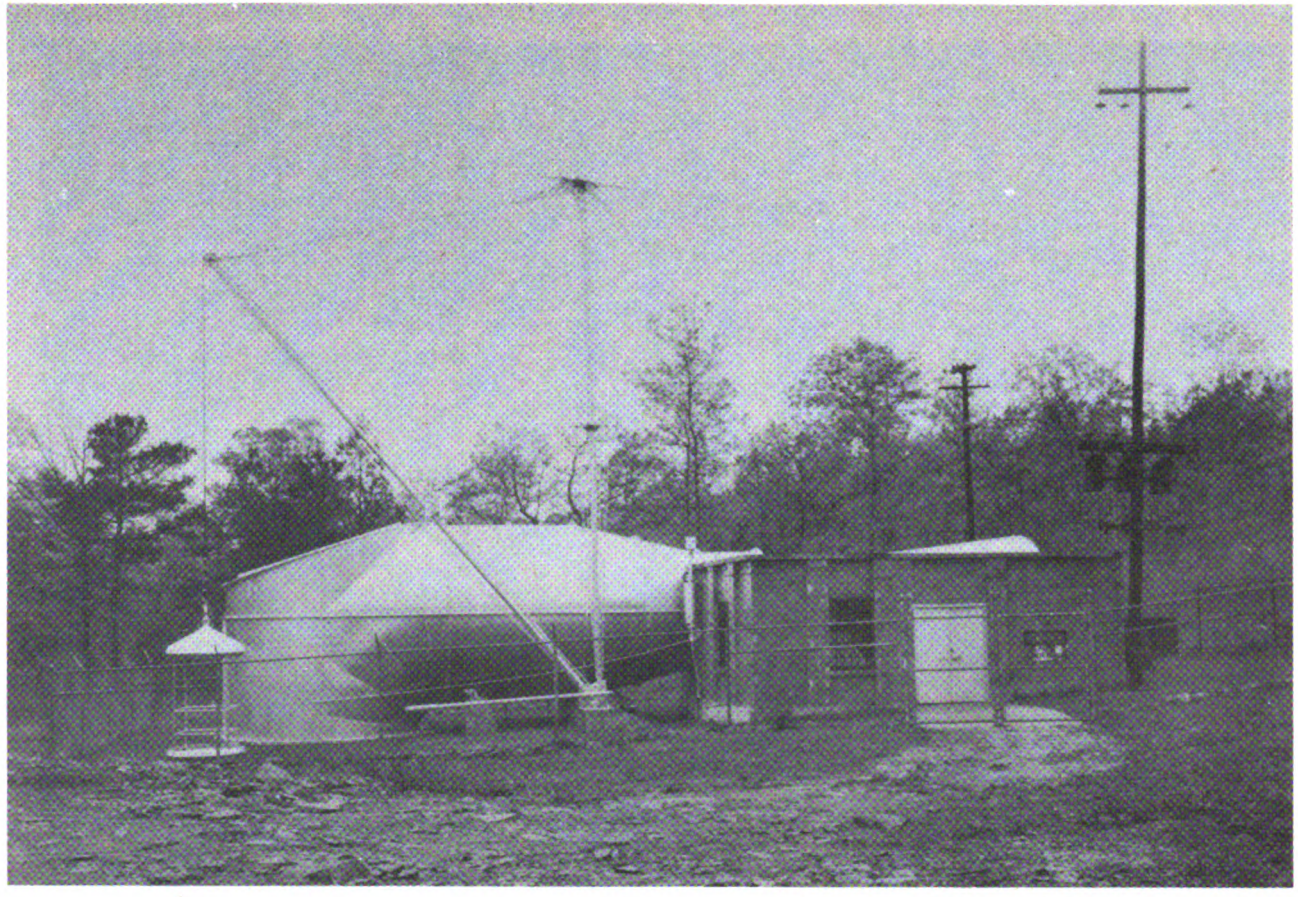

Figure 12. - General arrangement of emergency hoisting facilities.

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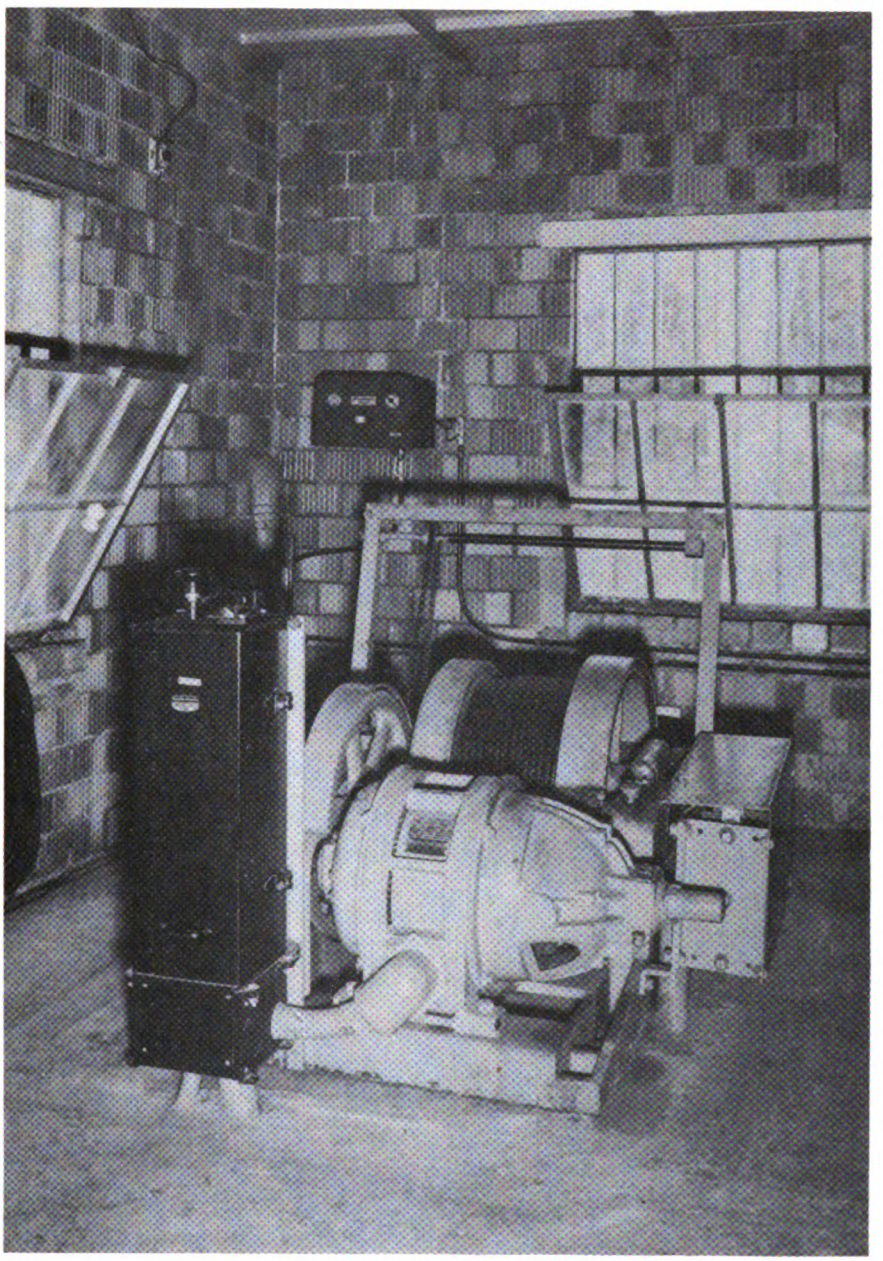

Figure 13. - Close up of hoist.

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Figure 14. - Close up of cage.

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forced to pass progressively through the cotton filter, the hopcalite, the calcium chloride, and then to the mouthpiece; whereas, the exhaled air bypasses these and is discharged into the surrounding air. The procedure to be followed in using a self-rescuer is shown on figure 10.

Hopcalite readily absorbs moisture, and its catylytic property diminishes accordingly. For this reason, the carrying case is hermetically sealed. Rough usage may destroy the seal, and the case should be examined frequently. A simple test for tightness is to immerse it in a pail of very hot water. If the seal leaks or the case has been punctured, a stream of bubbles will issue at the point of failure. If a leak is found, the self-rescuer should be discarded immediately and a new one obtained.

Fire Doors

Flexible control of the air currents is very important during fire-fighting and rescue and recovery operations. It is particularly desirable when trying to bypass a fire to rescue men inby. Doors erected at places such as near junctions are the quickest means of manipulating airflow. These doors are normally open, except those that are erected in lieu of stoppings. By placing doors in each opening at divisions and juctions of air splits, it is possible to manipulate the flow of air to suit most situations. Some companies have installed such doors, and they are held in the open position by a post, and on the floor nearby is a second post, to be used for dislodging the other post when it is desired to close the door. Their value is not limited to emergency use following an explosion or a fire, but they may be used to divert the entire volume of air if an outburst of gas occurs in one section of a mine.

Figure 11 shows how the doors may be used to rescue men inby a fire. A four-entry system is shown in which the two center entries are intake airways and the outer entries are return airways. By closing the emergency doors in the intake, air flow to the fire is reduced, if not stopped entirely, and the movement of fire gases from the fire zone to the working section is retarded, thus delaying contamination of the air in that section. By opening the doors separating the intake and return airways and closing the door in the return airway, intake air is coursed through the return airway and into the active sections, thereby providing an escapeway for the entrapped men and improving the chances for their escape and survival. The scheme, as shown, will work satisfactorily with any multiple entry system, providing the center entries are intake airways and the outer entries are return airways.

Emergency Hoists

It is not always economically feasible to install conventional or elaborate hoisting facilities at shafts used solely for ventilation, yet occasions may arise that justify enormous expenditures. Some means of travel, such as a ladder or stairway or a hoist, should be provided in each shaft. One company, not wishing to reduce the effective area of an untimbered air shaft, installed the hoisting equipment for emergency use shown in figures 12, 13, and 14.

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The hoist (fig. 13) is installed in the same room as the drive motor for the fan. It is a single-drum geared hoist driven by a 25 horsepower electric motor and mounted on a common bedplate. A mast and boom (fig. 12) serve as a head frame. The hoisting rope is reeved through a pulley at the top of the boom and through a metal fair-lead at the base of the mast and thence to the drum. The mast is supported by a concrete foundation and guy ropes. The boom revolves about the mast and can be swung in position directly over the shaft. The explosion doors in the top of the shaft hood are opened to allow the cage to enter and may be closed while the cage is operated in the shaft. The cage (fig. 14) is large enough to accommodate several persons. It is attached to the rope by a spelter-filled socket and a safety sling attached to the rope above the socket by clamps. Although it has never been necessary to use this equipment in an emergency, it is used occasionally to inspect the shaft.

Direction Signs

It is important that underground employees be familiar with all escapeways, manways, and other exits in addition to those usually traveled. Many men have lost their lives by wandering aimlessly after an explosion or fire. Direction signs should be placed throughout the mine indicating the routes to follow to the exits. Signs should not be confined to the active areas but should be placed in all open and accessible places as well. It is easy for persons to lose their sense of direction, particularly those not familiar with the general lay-out of the mine, when they deviate from the general and accustomed paths of travel. Also, the anxiety of trying to escape adds to the bewilderment.

Fire Drills

Fire drills for coal-mine officials and key employees should be held to acquaint them with the procedure to be followed in the event of a fire, particularly the location and the means of escape. It is unusual to find a coal company following this practice. General fire drills for mine employees may be advantageous in some mines; however, all employees should be informed of all ways of escape and what their duties are in event of fire. A few coal companies are doing this. They require the foreman in charge of each group of workers to prepare plans and procedures for removing the men in case of emergency. The plans are discussed at foremen's meetings, at which time errors are eliminated and a master plan for the entire mine is formulated. The frequency of presenting plans will depend upon the rate at which the mining area advances or retreats.

Barricades

Many miners have saved their lives by building barricades to protect themselves against poisonous gases following an explosion or a fire, and many others have lost their lives by not building them. However, barricading, to be effective, must be done in accordance with definite plans and procedures; otherwise lives may be lost unnecessarily. Reports of explosions and fires disclose that many who were unharmed by the flame and violence of an explosion perished when they encountered poisonous gases while attempting to escape.

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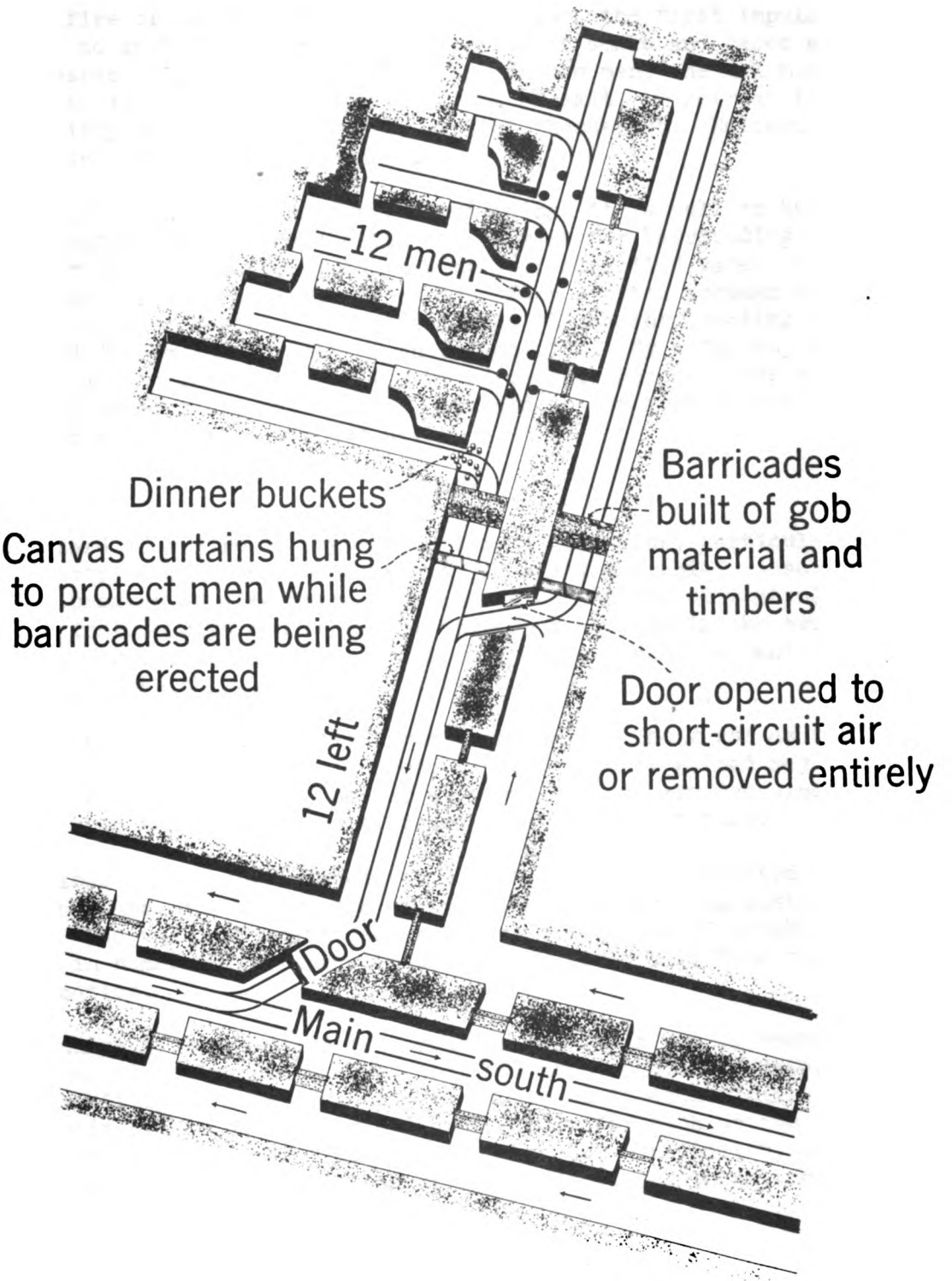

Figure 15. - Proper location and construction of barricades following a mine fire or explosion.

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When a fire or an explosion occurs in a mine, the first impulse of the survivors is to rush toward the nearest exit. If smoke and gases are encountered, especially if they are advancing on the men, the men must retreat and attempt to try some other possible means of exit, or retreat to some place where they must do something to protect themselves. Retreat is usually ended in an isolated part of the mine.

In anticipation of the need for barricading, it is well to keep a supply of suitable materials in each section of the mine for barricading. It should include one roll of brattice cloth, a supply of distilled water, boards, and tools, such as a saw, a hammer, and an ax. Each section foreman should, in anticipation of an emergency, select suitable places for erecting barricades (fig. 15) and inform the workmen of their location. By doing so, lives may be saved and aid to entrapped men may be hastened. Rescue crews need not waste time in unnecessary exploration, and aid in the form of boreholes from the surface may be started without delay.

SUMMARY

The hazard of a fire is ever-present in a coal mine, particularly mines that are electrified, because electricity is still the chief cause of mine fires. Any program of fire prevention and fire fighting or control must necessarily include ways and means for workmen to escape in the event a fire occurs. The legal as well as the moral obligation cannot be denied, and only by fulfilling these obligations will lives be saved.

Other benefits may be derived from escapeways. Their use as part of a ventilating system must not be ignored; the improvement gained may often be measured in dollars and cents, so far as power savings are concerned, and are incalculable with respect to efficacy in the event of fire.

Regardless of the completeness of a system of interconnected and continuous escapeways, the importance of expedients in escaping must not be overlooked. The value of self-rescuers, barricades, and direction signs has been proved in numerous instances in which many lives have been saved by their application.

The sinking of large-diameter boreholes and their use as emergency escapeways should be investigated by coal-mining companies to determine their applicability to local conditions. Where it is economically feasible, it may be desirable to bore a large-diameter hole for each active section, thereby providing an escapeway as well as improving ventilation, and for other uses, such as the installation of power lines, telephone cables, and water lines.

Finally, an escapeway, to be effective at all times, must meet the conditions established by the definition.

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